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A Note on Self-heating and Spontaneous Combustion of Stored Sunflower Seed Cake and Cotton Seeds

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Abstract: Sunflower seed cake and cotton seed warehouses combusted spontaneously and burnt in August and November 2009, respectively, in Khartoum North industrial area. The objective of this study was to determine some of the reasons for self-heating and spontaneous combustion. Representative samples from the two warehouses were collected. *Aspergillus niger, A. flavus, Paesiolomyces* sp., *Rhizopus* oryzae, *Absidia* sp. were isolated at 37°C. *Bacillus thuringiensis* was isolated at 37°C, and *B. pantothenticus*, *B. ciculans*, *B. licheniformis*, *B. sphaericus*, *B. badius*, *Escherichia coli* and *Klebsiella* sp. were isolated at 60°C. A decrease in oil, fibre and phosphorus and increase in free fatty acids and protein contents were detected.

Key words: Self-heating; combustion; sunflower seed cake; cotton seeds

Sunflower seed cake and fuzzy cotton seed warehouses were spontaneously combusted and burnt in August and November 2009, respectively, in Khartoum North industrial area. Both sunflower seed cake and fuzzy cotton seeds are liable to the risk of self-heating and spontaneous combustion (TIS 2000). Numerous authors reported the presence of *Bacillus* spp. in self-heating materials at thermophilic temperatures; species reported include *B. licheniformis*, *B. sphaericus* and *B. circulans* at 60°C and above (Storm 1985), and *B. badius and Aspergillus* spp. in composted biowaste (Ryckeboer *et al.* 2003). The objective of this study was to determine some of the reasons for self-heating and spontaneous combustion of stored cotton seeds and sunflower seed cake.

Representative samples from each warehouse were collected: (i) control samples (not affected by high temperature or humidity), (ii) samples subjected to high humidity level, and (iii) samples subjected to high levels of both humidity and temperature. Soil samples (10 cm deep) from the area of the burnt stacks were also collected. Sunflower seed cake and cotton seed samples were cultured in sabouraud dexterose agar at 37°C. After 2 days, slides were prepared, and the detected fungi were identified. Isolation and identification of bacteria were carried out at 37°C and 60°C according to Cowan and Steel (2004). Changes in the contents of oil, free fatty acids, total protein, ash, crude fibre and phosphorus were determined as percentages according to AOAC (1975) methods. The data were subjected to analysis of variance using GenStat Discovery edition 3.

Mesophilic and thermophilic microorganisms detected at 37°C and 60°C in the bunt stacks in the two warehouses are shown in Table 1. There were highly significant ($P<0.01$) changes in the percentages of all chemical components, except ash in cotton seeds and phosphorus in sunflower seed cake which showed no significant differences. There was decrease in oil, fibre and phosphorus and increase in free fatty acids and protein contents (Table 2).

Free fatty acids had a strong tendency to undergo auto-oxidation with oxygen, which results in considerable evolution of heat (flameless combustion). The fiber also enlarges the area exposed to oxygen and the distribution of oil and thus promotes self-heating (TIS 2000). Spook-lights and swamp gas fires originates from the spontaneous combustion of gases generated underground by fermentation process; the gases consist mainly of methane, phosphine (highly flammable at ambient temperatures at concentrations of more than 1.8 %) and diphosphine (spontaneously flammable reacting instantly with oxygen) (Massimo 2008).

The self-heating process in the stored agricultural products is an aerobic, solid-phase, natural, microbiological, chemical and physical process; factors like temperature, nutrient availability, oxygen concentration and water content affect the microbial community, and therefore chemical transformations and evolution of heat.

Table 1. Mesophilic and thermophilic microorganisms isolated and identified at 37°C and 60°C on sunflower seed cake, cotton seeds and soil from the area of the burnt stacks

Sample	Family	Temperature	
		37°C	60°C
Sunflower seed cake			
Fungi	Trichocomaceae	*Aspergillus niger*	
	Trichocomaceae	*Aspergillus flavus*	
	Trichocomaceae	*Paesilomyces* sp.	
	Mucoraceae	*Rhizopus* oryzae	
	Mucoraceae	*Absidia* sp.	
Bacteria	Bacillaceae	*Bacillus*	*B. pantothenticus*
	Bacillaceae	*thuringiensis*	*B. ciculans*
	Bacillaceae		*B. licheniformis*
	Enterobacteriaceae		*Klebesiella* sp.
Soil(seed cake store)			
Bacteria	Bacillaceae	*B. thuringiensis*	*B. licheniformis*
	Enterobacteriaceae		*Escherichia coli*
Cotton seeds			
Fungi	Trichocomaceae	*Aspergillus niger*	
	Trichocomaceae	*Aspergillus flavus*	
	Mucoraceae	*Rhyzopus* oryzae	
	Mucoraceae	*Absidia* sp.	
Bacteria	Bacillaceae	*Bacillus*	*B. badius*
	Bacillaceae	*thuringiensis*	*B. pantothenticus*
Soil (cotton seeds store)			
Bacteria	Bacillaceae		*B. badius*
	Bacillaceae	*B. thuringiensis*	*B. pantothenticus*
	Bacillaceae		*B. sphaericus*

Table 2. Changes in the percentages of free fatty acids, protein, ash, fibre and phosphorus of stored sunflower seed cake and cotton seeds after spontaneous combustion

Sample	Oil (%)	Free-fatty acids (%)	Protein (%)	Ash (%)	Fibre (%)	Phosphorus (%)
Sunflower seed cake						
Control	7.9	6.7	13.2	5.8	14.75	2.31
Subjected to high humidity	5.5	10.2	17.5	6.0	14.55	2.24
Subjected to high humidity and high temp.	4.1	10.9	14.2	6.9	12.50	2.12
SE ±	0.04	0.02	0.02	0.01	0.02	0.11
Cotton seeds						
Control	21.52	4.54	27.95	3.44	11.95	1.89
Subjected to high humidity	19.59	5.82	39.87	3.64	11.40	2.09
Subjected to high humidity and high temp.	17.25	7.45	40.64	3.09	8.20	1.48
SE ±	0.24	0.14	0.08	0.32	0.01	0.02

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التسخين و الأشتعال الذاتي لكسب زهرة الشمس و بذرة القطن المخزونة

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المستخلص: إحترق مخزنان بالمنطقة الصناعية في الخرطوم بحري في اغسطس ونوفمبر 2009 ، يحتوي أحدهما على كسب لبذرة زهرة الشمس و الآخر على بذرة قطن ، نتيجة لظاهرة الإشتعال الذاتي . الهدف من إجراء هذه الدراسة هو تحديد بعض الأسباب التي ادت الى التسخين والإشتعال الذاتي . أخذت عينات من هذه المخازن وأخضعت للدراسة . تم عزل و تعريف مجموعة من الفطريات في درجة حرارة 37^{0}م وهي *Aspergillus niger* و*A. flavus* و*Paesiolomyces* sp. و *Rhizopus oryzae* و*Absidia* sp. وأحد أنواع البكتيريا وهو *Bacillus thuringiensis*، كما تم عزل وتعريف . *B pantothenticus* و *B. ciculans* و *B. licheniformis* و *B. sphaericu* و *B. badius* و *Escherichia coli* و *Klebesiella* sp. في درجة حرارة 60م . كما لوحظ نقص في كمية الزيت والألياف و الفسفور و زيادة في كمية الأحماض الدهنية الحرة و البروتين .